Population Dynamics and Interactions between Plant Parasitic and Non-parasitic Nematodes: An Empirical Analysis

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ABSTRACT

Knowledge of pest populations is important to efficiently manage plant damaging organisms and achieve maximum expected profit. Non-linear regression models were used to estimate population dynamics, genera interactions, and nitrogen and crop rotation effects for plant parasitic and non-parasitic nematodes using data from the “Cullars rotation”. Because field experimental data was used, a spatial component was included as populations in one plot were proved to be influenced by the value of their neighbors. Own population dynamics were found to be very important for all taxa and all of them had an interaction effect with at least one other group. Lesion and cotton root-knot nematodes were found to be competitive while Mononchidae, Dorylaimidae, microbivorous and lance nematodes were non-competitive. All of the populations showed high seasonality patterns. Nitrogen had a positive effect on Mononchidae, microbivorous, spiral, and cotton root-knot. The use of clover after cotton in the rotation crop program proved to be the best in reducing plant parasitic nematodes.

INTRODUCTION

Agriculture has shifted from a classical/rigid farming system to the use of integrated crop production programs in order to become more efficient managing pests, financial risks, and environmental concerns. In this context, knowledge of population dynamics of soil-borne organisms is critical in order to developing flexible information-based farming systems that manage these organisms for maximum expected profit. There are almost no statistical studies on nematode population dynamics. Taylor and Rodríguez-Kábana (1999) presented statistical estimates, by means of regressions, of dynamic population models for three species (root-knot nematode, "white mold" fungus, and microbivorous nematodes) using observations from field experiments.

This study improves the population modeling approach introduced by the authors by including a spatial autocorrelation component in order to account for location effects between experimental samples. The model is also improved by including more plant parasitic nematode species: spiral (*Helicotylenchus* pseudorobustus), lance (*Hoplolaimus galeatus)*, stubby root (*Paratrichodorus minor)*, lesion (*Pratylenchus zeae*), and cotton root-knot (*Meloigogyne incognita*) as well as more non-parasitic taxa: Mononchidae, Dorylaimidae, and microbivorous. In addition to examining the interactions of eight taxa, the dynamic models are estimated with field observations made approximately monthly permitting a closer examination of the seasonality of populations’ growth and decline.

Figure 1. The Cullars rotation. Each number/letter refers to a different fertilization regime.

METHODOLOGY AND DATA

The model, a Cobb-Douglas panel regression, is expressed in linear in parameters as follows:

$$p_{it} = a_i + \theta w_i p_{it} + \sum_{j=1}^{n} b_{ij} p_{j,t-1} + \sum_{k} g_{ik} X_{ik} + u_{it}$$

Where p_{it} is population level of the ith organism at time t; w_i is the distance/connectivity (spatial) matrix; $p_{j,t-1}$ is population level of the genera interacting with the ith organism at time t-1 (including its own); X_{ik} is a set of k binary explanatory variables for the ith organism (nitrogen application, monthly intercepts, and crop rotation sequence); b_{ij} and g_{ik} are the parameters to be estimated; and u_{it} is a random error term.

Nematode counts were taken from plots in the “Cullars Rotation”. Soil samples were obtained from 4 of the14 soil fertility regimes (A, B, 1, 3) replicated in 3 non-randomized blocks (see figure 1). The 3-year rotation sequence on the 3 blocks is shown in figure 1. The soil fertility treatments for which nematode samples were taken all had lime, phosphorous and potassium, but differed in nitrogen fertilization (N or no-N) and legumes (with or without). Five subplots in each plot were sampled. A total of 60 samples examined in 28 periods, from January of 1993 to April of 1996, were used.

RESULTS

- Spatial matrix highly significant for all regressions.
- The lagged own-population effect was statistically significant for all genera except the microbivorous nematodes (only at 78%).
- Interaction of the various nematode genera were present
- Table 1: off-diagonal elements in lower block are negative, indicating that the cotton root-knot and lesion nematodes are competitive. Off-diagonal elements of upper block are zero or positive, indicating that those genera are not competitive
- Results of nitrogen, legume application and crop rotation are shown in table 2.

Table 1. Signed Community Matrix for Eight Nematode Genera

Nematode Genus	Nematode Genus Affected							
	Mononchidae	Dorylaimidae	Microbivorous	Lance*	Spiral*	Stubby Root*	Lesion*	Root-Knot*
Mononchidae		+	0	+	-	0	+	0
Dorylaimidae	0		0	0	-	0	0	0
Microbivorous	0	+		+	0	+	0	0
Lance	0	0	0		0	0	+	0
Spiral	-	-	-	0		0	+	0
Stubby Root	0	0	0	0	+		0	-
Lesion	-	0	0	0	0	0		-
Root-Knot	0	0	0	0	+	-	-	

Table 2. Directional Effects of Fertilization and Crop Rotation on Current Population Levels

Practice	Population of:							
	Mononchidae	Dorylaimidae	Microbivorous	Lance*	Spiral*	Stubby Root*	Lesion*	Root-Knot*
Nitrogen	+	0	0	-	+	0	0	0
Legume	0	0	+	+	+	0	-	+
Soybeans	0	0	0	0	0	-	+	-
Corn	0	0	0	0	-	0	+	-
Clover	+	0	0	0	-	-	-	-
Rye	+	0	+	0	-	0	+	0

* Plant parasitic genera. + denotes a positive effect, - denotes a negative effect, and 0 denotes no effect.

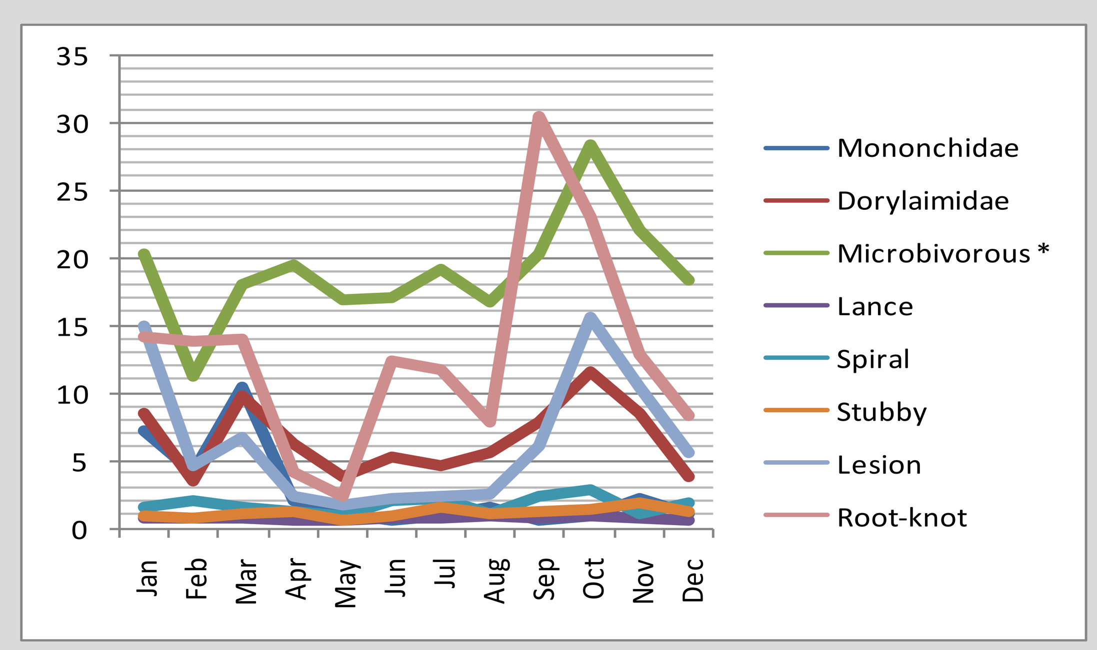

Figure 2. Monthly fixed populations by count. * denotes that the quantity was divided by 10 for formatting purposes.

- There are strong seasonality patterns for all nematodes except for lance, spiral, and stubby root. Populations go down during late winter (excepting microbivorous) to remain steady until September-October when there is a significant increase in the population of cotton root-knot, Dorylaimidae, microbivorous, and lesion.

CONCLUSIONS AND DISCUSSION

The effects of crop rotation and seasonality patterns found in this study tend to agree with what was previously found in the non-statistical literature. Overall, findings converge in that crop rotation sequences must be incorporated in the farmer’s cultural practices in order to properly manage plant parasitic nematodes. In addition, as it was stated by Taylor and Rodríguez-Kábana (1999), own population dynamics were found to be very important for all groups of nematodes. This study adds to the literature as it allows interactions between many taxa of nematodes and also controls for spatial relationships among samples.

REFERENCES:
- Taylor, C.R., Rodríguez-Kábana, R., 1999. Population Dynamics and Crop Yield Effects of Nematodes and White Mold in Peanuts, Cotton, and Velvet beans. Agricultural Systems 59, 177-191.